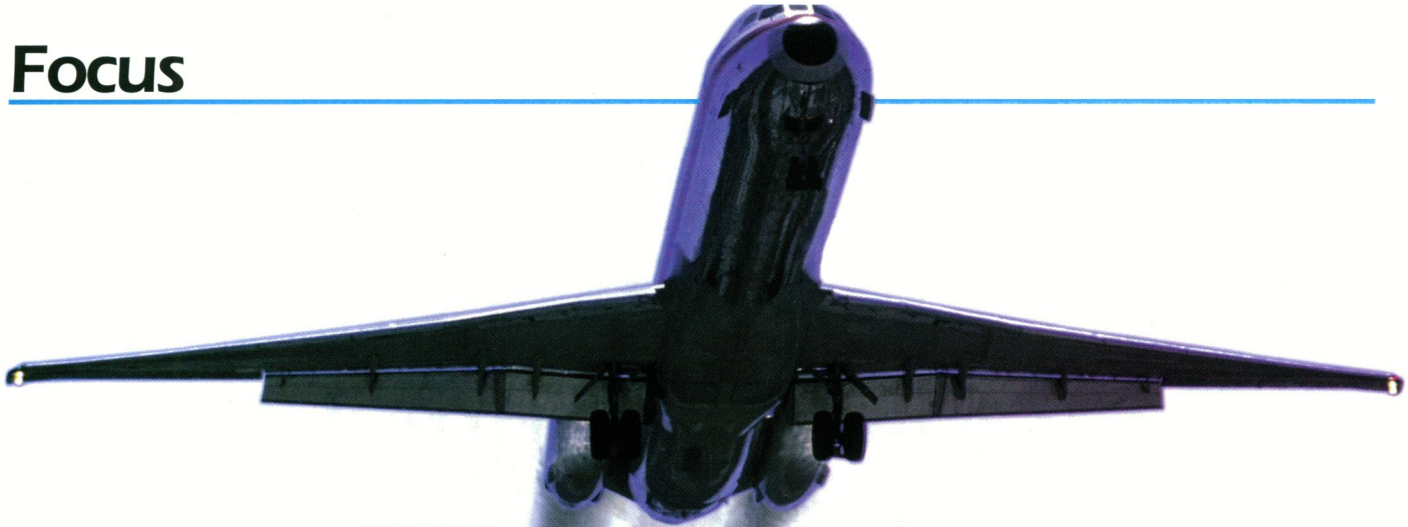


PLANE POLLUTION

In regulating aircraft and airports, several compelling interests compete: safety, international commerce, and environmental quality. Of these, safety issues receive perhaps most of the attention, garnering large headlines in the wake of airplane accidents. But the issue of the effect of airports on the environment and human health has heated up in recent years as public interest and citizen groups contest airport expansion on environmental and health grounds, and the airline and airport industries attempt to meet increasingly stringent regulations in these areas.

Airports are known to be major sources of noise, water, and air pollution. They pump carbon dioxide (CO_2), volatile organic compounds (VOCs), and nitrogen oxides (NO_x) into the atmosphere, as well as dump toxic chemicals—used to de-ice airplanes during winter storms—into waterways. But determining the extent of airplanes' contribution to local, national, and international levels of pollution is difficult—cars and airplanes entering and leaving airports produce roughly equivalent quantities of ozone precursors. Auxiliary power units (APUs), little jet engines in the planes' tails that power appliances while the planes are at the gate, and ground support vehicles also produce quantities of pollutants. And competing local and national political forces make airport pollution hard to regulate; much of the air pollution is local, but automobile and airplane emissions are regulated both nationally and internationally.

The growth of air traffic further frustrates mitigation of environmental problems. Air traffic is expected to double nationally by the year 2017 and internationally by 2010, according to the Federal Aviation Administration (FAA). At least 32 of the 50 busiest U.S. airports have plans to expand operations, according to a survey conducted by the Natural Resources Defense Council (NRDC), published in the environmental group's October 1996 report *Flying Off Course: Environmental Impacts of America's Airports*. According to the FAA, 60 of the 100 biggest airports want to at least build or extend runways.

Noise Pollution

Studies suggest that noise may harm health. Those who say they are bothered by local noise levels rate their general health more poorly than those who say they are not bothered by local noise, according to a study of two comparable communities in New York City, one of which is located in a flight pattern. Arline Bronzaft, professor emeritus of psychology at Lehman College in New York City and author of the study to be published in *Environment and Behavior*, urges caution in drawing conclusions from the study, however, because of its small size (270 subjects).

Noise also may interfere with learning. In a 1975 *Environment and Behavior* study of children who attended a school situated beside some railroad tracks, Bronzaft found that students who spent the entire six years of elementary school on the side of the school closest to the tracks were a full year behind students who had spent the entire six years on the quieter side facing away from the tracks. After later becoming a consultant to the New York City Transit Authority, Bronzaft was able to get that agency to install a noise abatement system on the tracks. She later retested the children and found that the reading level had become identical on both sides of the building.

In a 1993 review of the effects of noise on children, published in *Children's Environments*, Gary Evans, a professor in the department of design and environmental analysis at Cornell University in Ithaca, New York, found a variety of problems in children exposed to noise compared to children not exposed to noise: blood pressure elevated by 4–8 mmHg, learned helplessness, deficiencies in ability to discriminate words (possibly due to tuning out noise), and possible delays in cognitive development. Evans cautions that "there is a total lack of prospective, longitudinal designs in this research area," as well as a lack of precision in two aspects of procedural conditions during testing: uniformity and quiet.

Yet another reported health impact of noise is increased anxiety and levels of annoyance. For example, during the late 1980s, capacity problems forced rerouting of air traffic around New York City and Newark, New Jersey. Routes above areas surrounding those cities had to be layered four-deep in the vertical plane. Planes suddenly began passing 7,000–8,000 feet over the Catskill Mountains on their way into Newark International Airport, about 100 miles south. Major citizen protests ensued. The U.S. General Accounting Office was asked by Congress to examine the situation and concluded in its report that the FAA

had failed to account for expectations of quiet among people in rural areas, as well as the lack of urban background noise to mask the planes' drone. Planes continue to fly over Newark neighborhoods as far as 50 miles away from the airport at altitudes of as little as 4,000 feet, blasting residents with up to 78 decibels (dB) from the noisier planes, charges Michael Schatzki, president of the New Jersey Citizens for Environmental Research.

In an independent study on the effects of noise on people, Susan Staples, a psychologist in Stone Ridge, New York, found that factors concerning how people perceive and respond to their environment, such as expectations of noise level, are most predictive of annoyance level. In fact, mere loudness accounts for less than 50% of annoyance from noise, according to a 1993 literature review by R.F.S. Job of the University of Sydney in New South Wales, Australia.

Dealing With Noise

Takeoff from John Wayne Airport in Orange County, California, is like an "E" (for "exciting") ride at Disneyland, says Rick Fishel. Fishel's late father, Robert Fishel, then the noise abatement officer for the Orange County department of transportation and a former fighter pilot, designed the technique. "They put the brakes on, gun the engines, and then release the brakes, so it feels like a dragster," says his son.

The plane climbs like a rocket, says Fishel. It ascends and then starts to fall from the top of its arc, and the passengers feel their stomachs rising. Then the captain cuts the power—and the noise—and the plane essentially glides until it is far enough out over the ocean so that when the captain revs the engines again, the noise is nearly inaudible to the wealthy residents of Orange County.

Most airports are not so solicitous of the people who live around their flight paths. But protecting neighbors from noise is largely optional for airports. Airports apply for a grant from the FAA under the "Part 150" program (so named because it is located in Part 14, Section 150 of the *Code of Federal Regulations*) for money to buy out homeowners or install soundproofing if noise exceeds a threshold of 65 day–night average sound level (DNL). Sound levels are averaged for both night and day, but at night 55 dB counts as 65 to account for the fact that people are sleeping.

To mark the boundary of the threshold, a contour is drawn around the airport, like the contours on a topographic map. Of more than 500 commercial airports in the United States, 231 have participated in Part 150, according to the FAA. Fourteen of the 50 busiest airports are not participating, including LaGuardia Airport, which affects 195,000 people living inside its contour, and Miami International Airport, which affects 163,234, according to the NRDC.

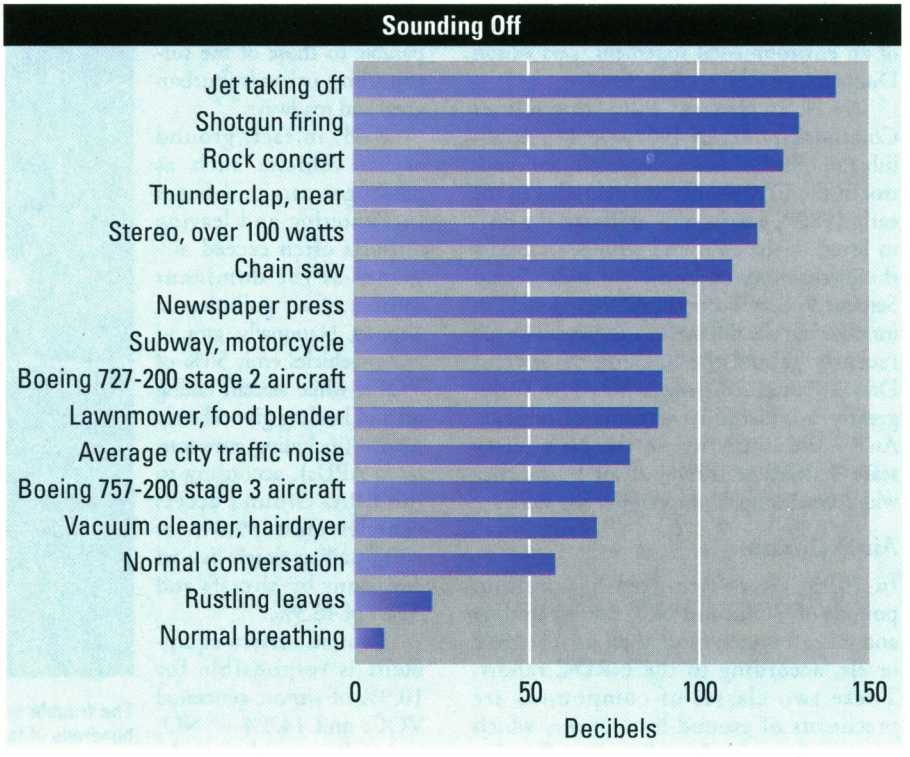
Critics charge that the 65 DNL is based on expediency; that is, what regulators feel can be accomplished without too much expense or difficulty. Complaints of noise abound from people outside of the contour. At the Westchester County Airport in suburban New York City, 95% of complaints fall outside of the 60 DNL contour, according to the NRDC. The group charges that the FAA's use of what the agency calls a "dose" of noise overlooks more subtle factors that determine how much noise annoys. For example, says Carolyn Cunningham, a consultant to the NRDC's airport project, spikes of noise, which can reach 105 dB or more, are far more annoying than a 65-dB drone. Other factors, such as expectation of noise and background noise, she argues, should also be taken into account

Thomas L. Connor, manager of the technology division in the office of environment and energy at the FAA, asserts that noise dose is the measure that best correlates with annoyance. "Sixty-five DNL represents where approximately 12% of the community would be highly annoyed," he says. Asked whether one might expect that if 12% were highly annoyed, a lot more people would be moderately annoyed, Connor says, "That is something that would be logical to deduce from that." But, he continued, "In terms of government policy . . . this is a level and amount of exposure that government can do something about reasonably and economically." In fact, the FAA has supplemented 65 DNL with other measures, says Connor, such as time spent above the 65-DNL threshold.

Some airports have voluntarily attempted to reduce noise impact. At San Diego International Airport in the past 10 years, the 65-DNL contour has shrunk from about 3 to 1.3 square miles despite increasing traffic, says Danette Lake, the airport's director of airport noise information.

The airport requires each carrier annually to increase the percentage of the new, quieter "stage 3" aircraft it flies into San Diego—or face fines. Additionally, a curfew on departures favors quieter aircraft with two extra hours of takeoff time. Since 1988, the percentage of stage 3 aircraft flying into San Diego has risen from 49% to 97%. In general, stage 3 aircraft are 10 dB quieter than stage 2 aircraft, which represents a halving of perceived noise, although actual noise reductions vary by aircraft, according to the NRDC report.

The San Diego program and similar noise reduction programs that exist at several other airports can no longer be implemented, however. In 1990, Congress



Source: *Environ Health Perspect* 102 (11):925 and *Flying Off Course: Environmental Impacts of America's Airports.* Natural Resources Defense Council, October (1996).

passed the Airport Noise and Capacity Act, which requires that, by the year 2000, all aircraft in commercial fleets weighing more than 75,000 pounds must be either stage 3 aircraft or stage 2 aircraft that have been retrofitted to dampen noise. For a plane flying 4,000 feet overhead, this would reduce the decibel level on the ground from 78 to 72, according to Schatzki's figures. Carriers have spent billions of dollars on this upgrade, says Thomas Bennett, an environmental specialist at the FAA. However, the Airport Noise and Capacity Act has made it virtually impossible to impose curfews or hasten restrictions on stage 2 aircraft because it would require proof that such restrictions do not unduly burden the national aviation system, says Lake. Moreover, the NRDC points out that, although stage 3 aircraft will decrease average noise levels, more planes flying in and out of airports will create more of the loud "single-event" noises (possibly reaching 90–100 dB) that are the most troublesome for airport communities.

The FAA requires airports to file environmental impact statements when they seek federal funds to expand, and such reports may be used in applications for Part 150 grants for noise reduction measures. The environmental statements are "mostly to help the public understand the impact of a proposed action," according to Connor. The FAA is required to consider public comments in response to environmental statements in making decisions, but has never rejected a proposed expansion because of an environmental statement, says Alison Duquette, an FAA spokesperson.

A U.S. Senate bill, the Quiet Communities Act of 1997, would reestablish the office of noise abatement and control in the EPA (which was defunded in the early 1980s), and would "challenge the FAA to listen to the EPA and seriously consider the environmental impact of noise," said Senator Robert Torricelli (D-New Jersey) in introducing the bill earlier this year. The bill recently gained the backing of Senator Daniel Patrick Moynihan (D-New York), greatly increasing its chances of passage. Anti-noise legislation in the New Jersey state legislature, aimed at air traffic, has widespread support throughout the state.

Air Pollution

In 1993, aircraft emitted 350 million pounds of VOCs and NO_x during landing and takeoff cycles, more than double 1970 levels, according to the NRDC report. These two classes of compounds are precursors of ground-level ozone, which can interfere with lung function. "During the summer . . . between 10% and 20% of all East Coast hospital admissions for respiratory problems may be ozone-related," says the NRDC report.

Airports are among the greatest sources of local air pollution. A major airport's idling and taxiing planes can emit hundreds of tons of VOCs and NO_x annually. John F. Kennedy International Airport is the second largest source of VOCs in New York City. LaGuardia is among the major sources of NO_x.

The VOCs emitted by airports may comprise a variety of toxic chemicals, according to a 1993 study by the EPA. Chicago's Midway Airport released more benzene and formaldehyde than most Chicago factories. But Jacob Snow, assistant director of aviation for planning and environment at McCarran International Airport in Las Vegas, Nevada, asserts that in the world of ozone precursor emissions, those from airports are of little consequence. "McCarran's VOC emissions [for 1993] were equivalent to those [produced by] the motor vehicles used by less than 9% of the nonattainment basin's households," he says. Similarly, a 1991 study by Argonne National Laboratory, funded by the FAA, concluded that "the impact of airport emissions on the surrounding air quality was not significantly larger than that of the background emissions. This implies that on a per-unit area of ground surface basis, the airport emissions are roughly comparable to those of the surrounding urban/suburban areas and roadways."

And, in fact, ground access vehicles such as passenger cars and buses just entering and leaving airports often exceed airplanes as the dominant sources of air pollution at airports. Nationally, ground access vehicles emit 56% of VOCs, while aircraft taking off and landing give off only 32.6% (including emissions from APUs), according to the EPA. Ground access vehicles emit 39.3% of NO_x, trailing closely behind emissions by aircraft and APUs of 46.3%.

Ground service equipment is responsible for 10.9% of airport-generated VOCs and 14.3% of NO_x nationally, according to the EPA. National figures for APUs were not available, but in southern California in 1990, APUs gave off less than 1% of hydrocarbons and about 6% of NO_x, according to the California Air Resources Board (CARB).

In 1993, one out of five U.S. citizens lived in a locale where air failed to meet national standards for ozone. Thirty of the nation's 50 busiest airports are located in ozone nonattainment areas, and three of these are located in the dirtiest nonattainment area, the Los Angeles–South Coast basin.

States that include nonattainment areas must develop state implementation plans (SIPs) for cleaning their air. But states have scant leverage to deal directly with airport pollution. States cannot regulate aircraft emissions for the same reason they cannot regulate automobile emissions. "Can you imagine every airport imposing different standards on 737s?" asks Ken Feith, senior scientific advisor in the EPA's office of air and radiation. So what can a SIP do? "If an airport is owned and operated by a state or local political jurisdiction, that jurisdiction has total control over ground equipment," says Feith. "They can impose restrictions as

The trouble with taxiing. Critics charge that taxiing airplanes emit hundreds of tons of greenhouse gases, but airport officials say these amounts are negligible compared to those from cars, buses, and other ground access vehicles.

long as they don't interfere with flight operations." For example, that jurisdiction can limit a terminal's number of gates.

One measure that could reduce emissions is single-engine taxiing. Single-engine taxiing saves fuel and reduces emissions substantially. Delta Airlines pilots generally use one engine to taxi, and at the airline's hub in Atlanta, this strategy saved $5.9 million in fuel costs in 1995 alone, according to the NRDC. But other airlines eschew or minimize the practice. Some airplanes lack the ability to taxi on one engine, says James Ericson, director of the office of environment and energy at the FAA. Furthermore, crews must be properly trained in the technique. Albert Prest, vice president of operations for the Air Transport Association, a trade group, says that the practice can be dangerous in certain circumstances, such as wet weather, because it may encourage the plane to slide or veer to one side.

The Case in California

But with 25–30 year lifetimes for jets, emissions from airplane engines will remain a problem long after the 2010 deadline for SIPs for extremely polluted areas such as Los Angeles to achieve air quality standards. According to projections by the CARB, aircraft NO_x emissions at so-called South Coast (the southern coast of California) airports will have doubled in 2010 over 1990 levels, to 24.8 tons per day or about 13% of 1990 levels. The board expects hydrocarbon emissions to drop somewhat, from 7.0 to 5.4 tons per day.

In contrast, the board expects ground access vehicle NO_x emissions, mostly from automobiles, to drop to 2.4 tons per day, or about one-quarter of 1990 levels. The projected reductions are due to California's stringent automobile air quality standards. But critics say the figures are optimistic because they assume a slower rate of growth than is actually occurring.

California's efforts illustrate the difficulties of cleaning air as population and travel explode. The California SIP incorporates a 50% increase in air traffic in the South Coast region, says Henry Hogo, planning manager for the South Coast air quality management district. "We try to balance economic needs with health," he says. "We want to allow growth and see if we can come up with ways of reducing emissions."

Nonetheless, in 1994 the state asked for the federal government's help to curtail reductions in federally regulated interstate transportation sources such as trucks and airplanes, says Hogo. A consultative process was set up between the South Coast district, the CARB, and the EPA to figure out how to achieve the necessary reductions. "The state assigned to the EPA the responsibility to reduce emissions from aircraft engines by a total of 8 tons per day through new standards," says Doris Lo, an environmental engineer in the EPA's Region IX. But a 16% reduction in emissions, recently proposed by the International Civil Aviation Organization, would not come close to delivering the required reduction. The proposed reduction is being opposed by two U.S. engine manufacturers—Pratt & Whitney and General Electric—as well as by the FAA, and is unlikely to be implemented.

The EPA is looking elsewhere for the 8 tons. The easiest emissions reductions could be had by powering ground service equipment with electricity and alternative fuels, and having aircraft at the gate plug into the terminal "instead of running those dirty [auxiliary] engines," says Lo. Nonetheless, these two sources represent a small percentage of VOCs and NO_x, and, so far, less than a ton per day of possible reductions has been identified.

Politics have stifled the South Coast district's own efforts to manage local air quality planning, critics charge. "The state legislature has taken away some of our authority in this area," admits Hogo. In 1994 the district had considered reducing passenger car traffic into airports. At the same time, it had proposed requiring owners of sporting event centers and shopping centers to develop plans to reduce vehicle trips into their locations, says Hogo. A cross-section of business interests pressured the state legislature to block the latter proposal; the legislative stone killed both birds.

Gary Honcoop, manager of the office of air quality and transportation planning at the CARB, refuses to discuss what other approaches to cleaning airport emissions might be explored, saying, "There is a lot of sensitivity because of the airlines involved and some of their concerns. I would hesitate to stir that process up by identifying too much specificity at this point."

Ozone Nonattainment Areas with Top 50 Airports

Nonattainment Designation	City (and Number of Airports if More than One)
Extreme	Los Angeles (3)
Severe	Baltimore, Chicago (2), Houston (2), New York (3), Philadelphia, Sacramento
Serious	Atlanta, Boston, San Diego, Washington, DC (2)
Moderate	Cincinnati, Cleveland, Dallas (2), Nashville, Phoenix, Pittsburgh, Salt Lake City, St. Louis
Marginal	Portland, Seattle, Tampa

Source: *Flying Off Course: Enivironmental Impacts of America's Airports.* Natural Resources Defense Council, October (1996). Original source: *Ozone and Carbon Monoxide Air Quality Data Update Fact Sheet,* EPA Technology Transfer Network.

NASA, however, is developing new engines that could reduce NO_x by 70% by the middle of the next decade. "We have a pretty good indication that [these levels] can be achieved," says Richard Niedzwiecki, a senior engineer in aeronautics for combustion and emissions research at NASA's Lewis Research Center in Cleveland, Ohio. Such engines could be in commercial aircraft as early as 2008.

Nonetheless, global warming will complicate further efforts to bring down emissions, says Niedzwiecki. To save on CO_2 emissions, he explains, aircraft weight must be reduced. But reducing NO_x requires engines with larger combustion zones. Furthermore, higher operating temperatures reduce CO_2 emissions, but raise NO_x emissions.

"There is now talk of seeking much more substantial CO_2 reductions, and we are putting a program together," says Niedzwiecki. He is "cautiously optimistic" that both CO_2 and NO_x goals can be met, but the time frame for doing so, he says, is 2010–2050.

Water Pollution

More than 4 million gallons of glycols were used for aircraft de-icing at 93 airports during 1989–1991, according to a survey by the FAA. Glycols are the most voluminous water pollutants from airports. As there are over 500 certified airports in the United States, the actual amount emitted may be much higher.

During de-icing, the airlines mix 55% glycol and 45% water, heat the mixture to about 185° F, and spray the planes down with it, says Miles Carter, manager of environmental services at Denver International Airport. Without recapture efforts, 50–80% of the glycols may end up in the local waterways, says Mark Williams, assistant environmental program manager for the Maryland Aviation Administration. Forty-five of the 50 busiest airports in the United States are within 3 miles of a major waterway, according to the NRDC report.

Other chemicals besides glycols that are used at airports may get into waterways, but information about these is sketchy. At Kennedy Airport, there are two underground lakes of jet fuel, estimated to contain 3–5 million and 6–9 million gallons, respectively, according to the NRDC report. The New York State Department of Environmental Conservation has ordered the airport to remove the fuel.

But glycols receive the most attention. Ethylene glycol is both more effective and more toxic than propylene glycol. The lethal dose for humans of ethylene glycol is a little over three ounces, according to a report prepared for the EPA. Less can damage kidneys. Propylene glycol is relatively innocuous. However, both ethylene glycol and propylene glycol consume high levels of oxygen during decomposition, according to the Airports Council International, a trade group in Washington, DC. This can deplete waterways of oxygen and kill fish.

The NRDC complains that regulations for disposal of de-icing chemicals lack teeth. The stormwater pollution prevention plans (SWPPPs) required of states under the Clean Water Act should greatly reduce contaminated stormwater discharges from airports if implemented as required, according to the NRDC report. But, the report continues, "It is not clear when, or if, the plans will be inspected by a regulatory agency." In addition, "SWPPPs must be made available only to regulatory agencies, not the public," which impedes the ability of citizen groups to ensure proper implementation. Says Bennett, "I find that impossible to believe, but compliance is up to . . . the states."

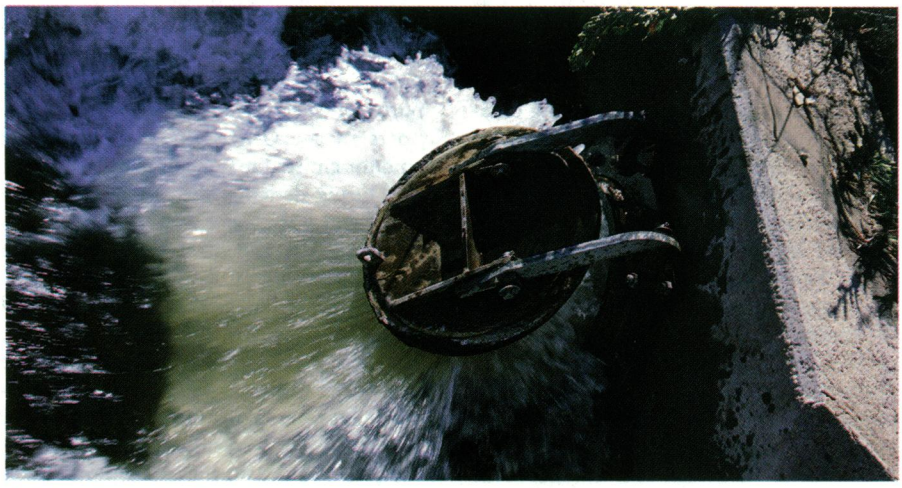
Furthermore, only those airports using an annual average of 100,000 gallons or more of de-icing fluid will be required to monitor or sample, according to the NRDC. These represent either 4 or 10% of airports nationwide, according to figures by the American Association of Airport Executives and the FAA, respectively. Bennett defends the air transportation providers, saying that the NRDC has provided no evidence that airports are not meeting established regulatory standards. He adds that, although these contituencies have the right to participate in development of regulatory standards, they have no authority to make a final determination of what those standards are.

Environmental meltdown? Glycols and other chemicals used to de-ice planes during storms can be toxic to animals and humans.

A small number of airports are very successfully recapturing glycols following use. According to the Airports Council International, 14 of 48 airports surveyed had containment systems for recapturing used glycols. Six airports prepared them to be recycled for other uses.

At Maryland's Baltimore/Washington International Airport, an estimated 25% of glycols are collected following de-icing. That doesn't mean that 75% find their way into the waters. Some of that amount evaporates or goes into the ground, where it decomposes in about 4–20 days, says Williams. The FAA is developing a new model to try to determine how much glycol actually gets into the water.

Baltimore/Washington uses two de-icing pads near the end of the runways to retrieve the glycols. The pads, big parking areas, are sloped to shunt de-icing fluids from beneath the plane, along with any precipitation that lands there, down one drain. Stormwater collected elsewhere goes down another drain. Baltimore/Washington also uses "glycol recovery vehicles," vacuum sweepers that "look sort of like street sweepers, that suck up the glycol and any liquid on the pavement," says Barbara Grey, manager of environmental plans and programs for the Maryland Aviation Administration. The glycol is piped to a



Watching the water. Stormwater pollution prevention plans could greatly reduce the amount of glycol-contaminated water discharged from airports.

huge tank, and then released very slowly over months to the sewage treatment plant.

At the Denver airport, which was designed to optimize collection of glycols, 65–70% of the fluid is recaptured, says Carter. These glycols are concentrated to a relatively high 25% on average, depending on the duration and nature of the precipitation.

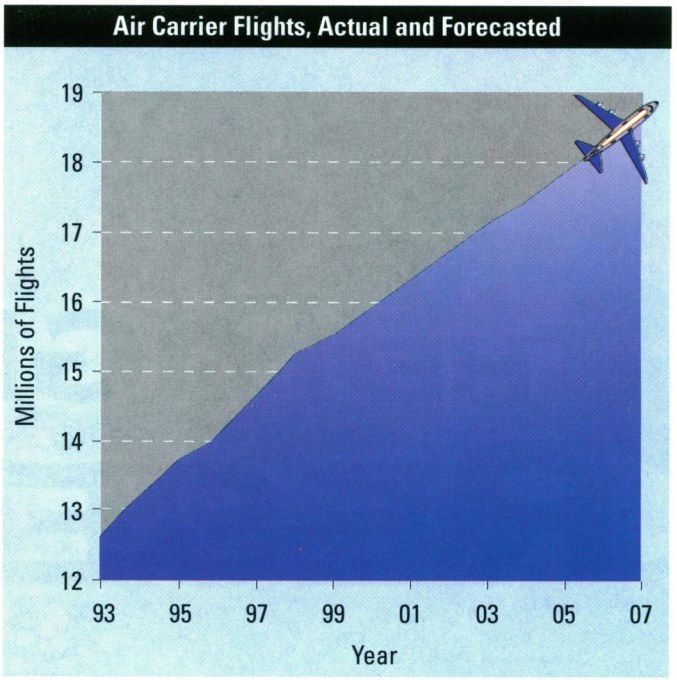
Recyclers increase the concentration to as high as 99.5%. "We recycle it for coal companies, some paint manufacturers, and General Motors," says Carter. But in the United States, recycled glycols are never used for de-icing, unlike in Europe. "The American manufacturers of glycol have convinced the U.S. airlines that it is a liability to use recycled glycol, although the same airlines use it in Europe all the time," says Carter.

A technological fix that could render de-icing chemicals partially obsolete is the use of infrared rays to heat the exterior of the plane. In such a process, immediately before takeoff the plane would pull into a hangar-like structure outfitted with the infrared energy process units and park there for approximately six minutes while the de-icing takes place.

"I'm really thrilled about it," says Robert Stone, manager of Buffalo Niagara International Airport, where the technology is about to be tested. Capital costs for the process, which are less than $2 million, are far less than the cost of systems to recapture de-icing fluids, which can range into the tens of millions. Six planes can be de-iced for $100–200 worth of gas and electricity, while a single de-icing with glycols can cost $2,500.

Future Flight

The projected doubling of passenger air traffic within the United States in the next 20 years, as well as the rapid growth of the U.S. population (which every 11 years adds the equivalent population of another California), virtually ensures that the environmental impact of airports will increase unless strong mitigation measures are taken. It is likely that population pressure will lead to greater numbers of people living near airports, even if not within the 65-DNL contour. Even as planes become quieter, increasing numbers will ply the skies, exposing people within the flight pattern to more, if perhaps softer, booms. The 25–30 year lifetime of airplanes will keep large numbers of today's polluting engines aloft long after technological solutions begin to make significantly cleaner engines available. And technological advances in the area of de-icing have been slow coming, potentially allowing toxic chemicals to continue to be released into groundwater. Says Feith, "I think that none of us, even here at EPA, have given substantial thought as to what are potential solutions to the problem of airport pollution."



Source: *Flying off Course: Environmental Impacts of America's Airports.* Natural Resources Defense Council, October (1996). Original source: FAA Aviation Forecasts: Fiscal Years 1996–2007, Office of Policy and Plans, Table 33, March (1996)

David Holzman